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Abstract
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THE DARPA INVESTMENT STRATEGY IN QUANTITATIVE NDE

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ABSTRACT

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INTRODUCTION

This morning I would like to attempt to provide you with some insight into the quantitative NDE program supported by the Defense Advanced Research Projects Agency. Specifically, I will address the following areas:

1. A personal view of the potential role of quantitative NDE on the mission of the Department of Defense or why invest in NDE?

2. A discussion of the criteria by which we make our research investments in this area.

3. A short overview of our present program, and

4. Some of the future directions and/or opportunities that this program must address in the not-too-distant future.

WHY INVEST IN NDE?

This subject could easily form the basis for an extensive monolog if not a large book; however, if you will permit me to present a rather simplistic, eclectic rationale, I believe I can relate progress in NDE to our overall military capability.

The initial budget request for the Department of Defense for FY79 may be displayed in a simplified manner as inputs consisting of allocations for RDT&E, Procurement, Operation and Maintenance and Military Pay and outputs consisting of Strategic, General Purpose and Airlift and Sealift forces.

However, the effectiveness of the outputs of the Department of Defense, i.e., the military forces) are significantly reduced due to scheduled and unscheduled maintenance. The availability of weapons systems certainly varies, but an overall estimate of 70% would not be unreasonable. Therefore, we are not obtaining perhaps 30% of the military capability achievable if all our systems were failure and maintenance free. Clearly, if we could predict the failure of systems and schedule the necessary maintenance, we should be able to increase the availability of weapons systems and achieve a significantly enhanced military capability for the same or possibly lower defense costs. In addition, the ability to predict failure has a major impact on all of us in its intrinsic ability to increase the safety of systems, such as aircraft, automobiles, nuclear reactors, etc.

We have also learned, in principal, how this technology may play a key role in minimizing life cycle costs by permitting us to make conscious tradeoffs between acquisition and in-service related costs. Conceptually, there is an optimum inspection criteria that minimizes the total life cycle cost of a component by minimizing the sum of the manufacturing and failure related costs.

The major technical challenges limiting the application of this methodology include the problem of obtaining the necessary data, such as the initial flaw distribution, required for the calculation of the probability of failure, as well as the practical problem of assigning reasonable failure related costs.

In summary, we have two major reasons for investing in the development of a quantitative NDE capability: the potential of increasing the reliability and availability of weapons systems and as a necessary component in a life cycle costs minimization effort.

As pointed out in a recent NMAB report, the cost savings possible with advanced NDE will not be obtained by reducing the already small direct costs currently associated with inspection, but rather, by taking advantage of the leverage this technology provides in developing a holistic approach to life cycle management.

INVESTMENT CRITERIA

Now I would like to discuss briefly our research investment criteria at DARPA and the scope of our technical interests in this area.

We must ask ourselves four basic investment questions before initiating any new program at DARPA. They are:

1. What are your trying to do (objectives in terms of today's capabilities)?

2. What makes your approach unique (reasons for confidence in view of risks)?

3. Assuming success, what difference will it make (translation of technology impact - market question)?

4. When can we expect results and how much will it cost (milestone plans)?

In addition, it should be noted that DARPA is charged with fulfilling the corporate or central research function for DoD and does not generally support programs that may only impact one of the Services or is aimed at solving a specific Service problem.

In the area of NDE, we do not support programs that are aimed at increasing the sensitivity of non-quantitative NDE techniques or reducing the cost of using conventional NDE procedures. Rather, our efforts are focussed on developing and demonstrating a quantitative measurement capability so that we will have a rational basis for making accept/reject decisions.

There is one other major consideration that I personally look for, and that is a champion, a person who is committed to achieving the goals of the program and has committed his professional career to that end. The next most important attribute is good communication between the sponsor and the research performer. All too often, we do not achieve the desired objectives because they were never fully understood by both parties.

THE PRESENT DARPA PROGRAM IN NDE

The present DARPA supported program in NDE primarily utilizes ultrasonics or stress wave propagation to inspect a structure. The decision to emphasize one technical approach was a conscious one in that it was decided that ultrasonics has the greatest ultimate potential, and the area of greatest interest in research laboratories. It was also decided that we would not disperse our resources among too many approaches in order to minimize the possibility that not meeting the objectives was due to financial rather than technical limitations.

The program we are reviewing at this meeting has formed the core of our investment in the NDE science base. Perhaps the greatest achievement of this program is that NDE now is a reasonably acceptable area in which to perform research. The joint support of this research by DARPA and the Air Force is precedent-setting and I believe has significantly contributed to the overall success of this effort. Since this meeting is the technical forum in which this program is reviewed, I will not attempt to outline the objectives and scope of this program. We have enlarged the initial scope of the program somewhat in that we now have a growing effort utilizing electromagnetic inspection techniques for surface flaw characterization. Hopefully, in this program, we will develop methodologies that will permit us to use whatever combination of techniques is necessary in order to obtain the required data for the characterization of structural defects.

We have increased our investments in demonstration test beds significantly in the last year. We are now supporting an engine disk "retirement for cause" study with Failure Analysis Associates, as well as two ultrasonic test beds; one with the Rockwell Science Center and the other with Adaptronics and Battelle NW. There are more detailed presentations scheduled during this meeting on each of these programs. So once again, I will defer to other speakers for a detailed discussion of the objectives and approaches.

Another program that will be presented during this meeting is one with Battelle NW to develop an inflight Acoustic Emission System for use on an Australian Air Force jet trainer.

We are planning to initiate a program to develop a portable ultrasonic imaging system that will have the capability of replacing conventional "A" scan pulse echo systems for a wide variety of applications.

The DARPA investment in NDE has been growing rapidly. In FY 75, the NDE program was funded at slightly less than $500,000 while in FY 79, the program has grown to an expenditure rate of over $2,500,000 per year.

FUTURE DIRECTIONS/OPPORTUNITIES

In the following discussion of future directions, it must be understood that there are many technical, financial and institutional issues that could cause a radical change in our program. However, at this point in time, I can describe how I see this program evolving.

Our support for the NDE Science Base I see focusing to a large degree on coupling the NDE measurement tasks with the "effect of defects" area. The program that Tony Evans will present on the NDE of ceramic components is one example of the type of program I would like to see for all structural materials. I believe it is time we broke down the artificial barriers between the NDE and life prediction or fracture mechanics community and developed a new technology base that can actually be utilized for quantitative life prediction.

The insights necessary to develop and implement rational accept/reject criteria will only be developed by a collection of a few individuals willing and able to chart new areas in materials sciences. We are going to have to work closely with the Services to arrange for tri-Service support of this program, since DARPA, by its charter, cannot institutionalize research and that is just what is needed today.

I expect our investments to shift more towards the demonstration test bed area in such areas as engine disk retirement for cause, inflight monitoring, and in process inspection and control.

There is one additional horizon or goal that deserves special mention - and that is the coupling of a quantitative life prediction capability into the design phase. It is clear that we gain the greatest benefit at the least cost by making the "right" design initially. How do we incorporate advanced manufacturing methods, NDE capabilities and inspection intervals in the design process, so that we can be confident of obtaining a given level of reliability for a system in the design phase, rather than only after it is deployed. We are still seeking the ability to manufacture Oliver Wendell Holmes' "one-hoss shay."